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ABSTRACT

This is one of a series of 14 instructional components of a semester-long, environmental earth science course developed for undergraduate students. The course includes lectures, discussion sessions, and individualized learning carrel lessons. Presented are the study guide and script for a learning carrel lesson on minerals. A public hearing is simulated to provide evidence concerning controversies. The slides, audio-cassette tape, and other materials necessary to the lesson are not included. (BT)

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STUDY GUIDE AND SCRIPT

SECTION IV: NATURAL RESOURCES

LESSON 6.10: MINERALS

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
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ENVIRONMENTAL STUDIES

A Cooperative Project of The Department of Geological Sciences and the Science Education Center

The University of Texas at Austin

SE 028 783

ENVIRONMENTAL EARTH SCIENCE

"Environmental Earth Science" is a new course developed at The University of Texas at Austin by the Department of Geological Sciences and the Science Education Center. It is offered at The University of Texas at Austin as Geology 361K and has been tried out during the spring semesters of 1972, 1973, 1974, and 1975. Revisions have been made as necessary after each tryout. The project within which the course has been developed has been supported by the National Science Foundation.

The course includes lectures, discussion sessions, and individualized Learning Carrel Lessons. Extensive use has been made of multi-media technology in the presentation of the course. Learning Carrels for individualized instruction have been especially designed for this program. The lectures introduce specific topics, suggest problems or questions, and provide background information. The discussion sessions provide the student an opportunity to ask questions and clarify ideas. The discussion sessions also provide input and feedback to the instructor.

The Learning Carrel Lessons have been written by faculty and graduate students in the geological sciences and in science education. Writers and resource contributors include Dr. Robert Boyer, Dr. Rolland Bartholomew, Dr. Keith Young, Dr. Samuel Ellison, Dr. James Underwood, Dr. David Butts, Dr. Addison E. Lee, David Keller, Melanie Lewis, Wayne Schade, Ann Lee, and William McLoda. Technicians involved in production of scripts, sound, and photography were Stan Prescott, Lee West, Charles Geffen, and William McLoda. Artists were Jesus Rivas, Alice Canestaro, Aly Knox, and Javier Flores.

Each Learning Carrel Lesson consists of a set of 2 x 2 slides, an audio cassette tape, a study guide, a script, and other materials necessary to the lesson. The study guide and script are in this booklet. Students may set their own time schedule within an announced period when slides and tapes are made available.

The student should note the list of Learning Carrel Lesson topics to place in proper content the lesson in this booklet, and then read carefully the introduction, rationale, prerequisites, and lesson objectives in the study guide. The student should follow the instructions in the study guide for the entire lesson. In some instances, these instructions are also repeated on the audio cassette tape. The slides and tapes have been synchronized to automatically advance the slides appropriate to the audiotape. However, there is a tone signal given before the change of each slide so that the lesson can be used outside of the carrel if automatic facilities are not available. When the student is ready to start the lesson, the "on" switch should be pushed. If the slides and tape are operated manually, both will need to be turned "on." The first slide is always a title slide or a blank solid colored slide. If

the slides and tape are manually operated, this title or blank slide should be on view before the tape is started. For automatic operation, the slides and tapes will be set up by the Instructor or Proctor before the lesson and between each use. It is most important to start each lesson according to these instructions in order to provide synchronization of the slides and tape. Remember that slides placed in the tray to be used with a rear view screen are reversed from those to be used with a front view screen.

The student will be instructed by the study guide and/or the tape to stop at various places to carry out certain activities. Usually the audio-tape will say, "Please stop the tape now and restart only when you have finished this exercise." Therefore, the student should wait a few seconds to finish hearing the instruction after the word "Stop." However, one should not wait long enough for the tone signal or automatic change to the next slide. This signal should be heard after you restart the tape. If the lesson is moving too rapidly, the student may stop the tape and slides at any time to consult the study guide or script, but it is NOT POSSIBLE to back up and re-examine a given slide without completing the entire cycle of the lesson.

It is particularly important for the student to carry out the instructions for activities given in the study guide. In order that a record may be maintained of these activities, each student should pick up a copy of the STUDENT RESPONSE SHEET which include questions to be answered and the other activities requiring responses. These should be completed and turned in to the instructor as required for grading, feedback for the instructor, and to provide a basis for student interaction in the discussion group.

Each Learning Carrel Lesson is independent within the context of the course. Some of them provide direct information on a given topic, but in an individualized mode requiring some activities and thought on the part of the student. Others place the student in a role-playing situation where some position must be taken on provocative questions or issues. Others deal primarily with applications of environmental information. In all the lessons, the student is expected to receive basic information that is coordinated with the lectures, the small group discussions, and the readings.

ENVIRONMENTAL EARTH SCIENCE

LEARNING CARREL LESSONS

Section I: Man's Effect on Nature

Lesson 6.1: Population
Lesson 6.2: Land Use
Lesson 6.3: Urban Crisis (Field Trip)

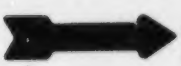
Section II: Energy

Lesson 6.4: Energy
Lesson 6.5: Energy Resources
Lesson 6.6: Future Projections

Section III: Processes Through Time

Lesson 6.7: Geologic Time
Lesson 6.8: Long Term Events
Lesson 6.9: Short Term Events

Section IV: Natural Resources



Lesson 6.10: Minerals
Lesson 6.11: Conflicts of Interest
Lesson 6.12: Soils
Lesson 6.13: Water

Section V: Oceanography

Lesson 6.14: Ocean Resources
Lesson 6.15: Pollution of the Oceans

STUDY GUIDE FOR LEARNING CARREL LESSON

6.10

MINERALS

ENVIRONMENTAL STUDIES

A Cooperative Project of the Department
of Geological Sciences and the Science
Education Center

THE UNIVERSITY OF TEXAS AT AUSTIN

TO THE STUDENT:

This booklet contains two sections: (1) the Student Study Guide for this lesson, and (2) the Script or printed copy of the discussion recorded on the audio cassette tape.

You are expected to begin with the printed instructions in the Study Guide and follow them continuously as you study the lesson. In many instances the same or similar instructions may also be heard on the audio cassette tape. Refer to the script only if you need to refresh your memory as to something that was said. The script is provided because you cannot back up the tape if you need to review something already said on the tape.

Specific instructions will be given in the Study Guide as to when to start and stop the tape. Do not restart the tape until instructed to do so in the Study Guide.

Questions requiring written answers should be completed on the STUDENT RESPONSE SHEETS provided by the Instructor.

INSTRUCTIONS:

1. Start the audio cassette tape and slides. (For manually operated slide carousels, be sure the slide on the screen is the title slide or the blank colored slide in slot number one. Otherwise, the slides and tape will not be synchronized.) Listen to the tape and view the title slide. As soon as the bailiff says, "You may be seated, the judge is with us," STOP THE TAPE AND SLIDES and read the Introduction, Rationale and Objectives of this program.

INTRODUCTION:

The format of this program is somewhat different from some of the others in the course. It is recognized that there is a need for more public information on our mineral resources. What mineral resources do we have? How much? Are we using them too fast? Are they renewable? Are there substitutes? What can we do about problems associated with mineral use and/or abuse? There are many questions and many of them are controversial.

To illustrate this situation, a public hearing is simulated to provide evidence concerning certain controversies. Part of the hearing will include a debate from representatives of two groups with opposing views.

You are to be the judge for this hearing and your verdict will be given at the end of the lesson.

GOALS AND RATIONALE:

This program was developed in order to (1) show the complexity of what appears to be a valid, acceptable statement regarding mineral resources, namely, "Minerals are finite in amount and essentially nonrenewable," and (2) cause the student to examine and define his own opinion regarding this statement.

OBJECTIVES OF THIS LESSON:

At the end of this program the student should be able to:

1. obtain information from and interpret graphs that show reserve-life in years of consumption and reserve-life in years of production

2. apply the arguments presented in the program to his own opinion about the statement, "Minerals are finite in amount and essentially nonrenewable."

3. identify gaps in the information presented in the program

INSTRUCTIONS:

2. A summary of the points presented in this program is provided in the Study Guide. It should not be necessary to take notes during this program. Therefore, sit back and follow the arguments so you can render your verdict at the end of the lesson.

Listen to the tape and view the slides until the bailiff calls for a recess and tells you to stop the tape. Then STOP THE TAPE AND SLIDES and answer Questions 1, 2, 3, and 4 on your STUDENT RESPONSE SHEET. For your information, graphs showing appropriate data are shown on the following pages.

EVIDENCE PRESENTED BY THE STOP MINERAL RESOURCE ABUSE GROUP

Look at either the graph of Reserve-Life in Years of Consumption (page 4) or Reserve-Life in Years of Production. The number at the end of each bar represents the years of supply of that commodity as determined by 1960 rates of production or consumption.

Assume that no new reserves are added and that there is no change in per capita consumption or technology.

Question 1

How many years of reserves at 1960 consumption and production rates remain for the minerals listed below? (USE STUDENT RESPONSE SHEET)

Mineral	Years of reserve at 1960 consumption rate	Years of reserve at 1960 production rate
a) Copper		
b) Manganese		
c) Cadmium		

Question 2

Notice that for many commodities the reserve-life in years of production is a larger number than the reserve-life in years of consumption. This means that the rate of production is too SLOW to keep up with the rate of consumption, therefore, the production reserve-life is longer. (The longer the bar, the slower the rate.)

List the commodities according to whether consumption rate exceeds, is equal to, or is less than production rate. Determine what percent of the total number of commodities is represented by each list. (USE STUDENT RESPONSE SHEET)

Commodities for which:

Consumption rate exceeds production rate	Consumption rate equals production rate	Consumption rate is less than production rate
____% of total commodities	____% of total commodities	____% of total commodities

Question 3

If the United States cannot produce for itself the quantity of commodities it needs, from what source(s) will the commodities come? (USE STUDENT RESPONSE SHEET)

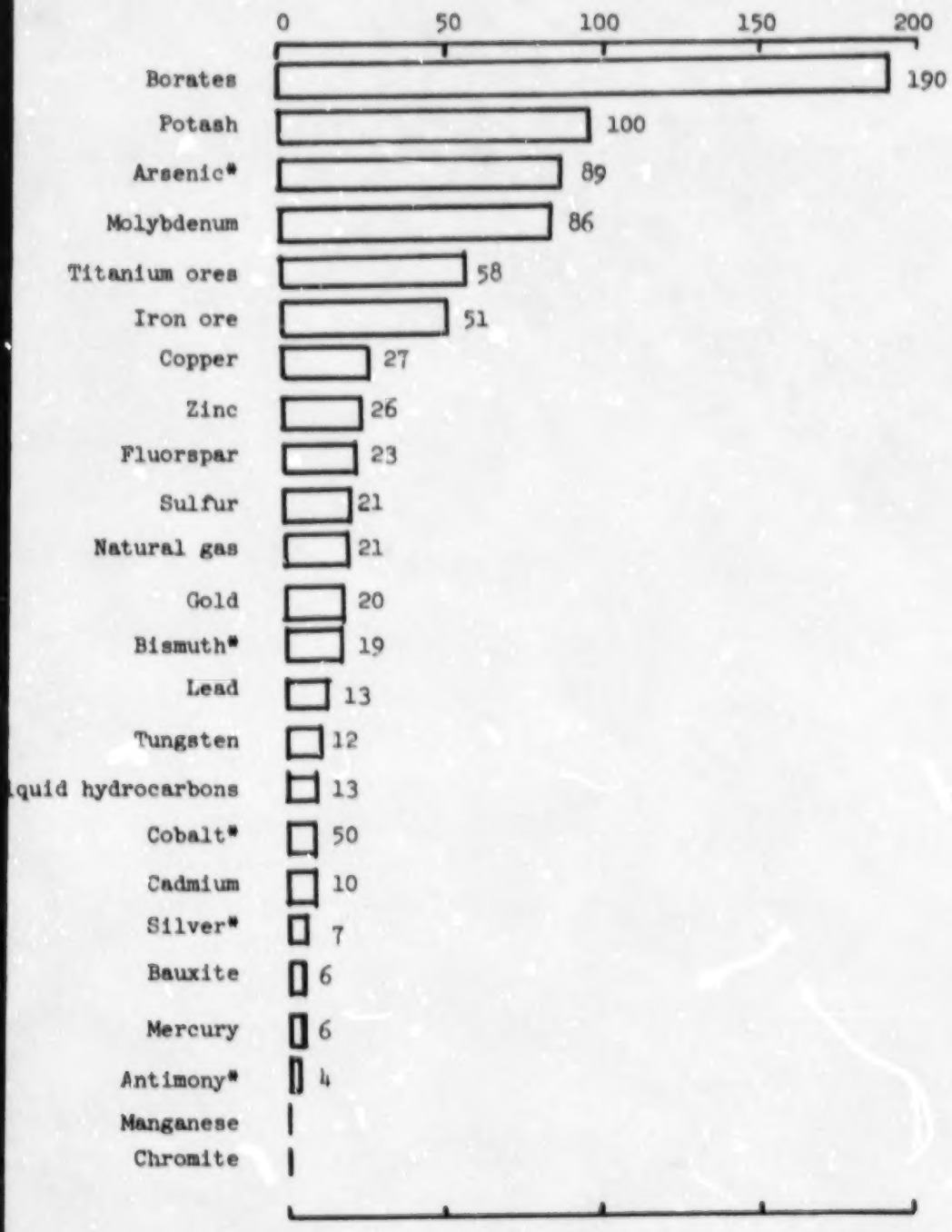
Question 4

At 1960 rates, how many commodities have a reserve-life in years of production that is 25 years or less? What fraction of the total number of commodities is this number? (USE STUDENT RESPONSE SHEET)

Note: You may want to refer to the list of commodities on the following pages in order to find out uses, and in some instances substitutes, for each commodity.

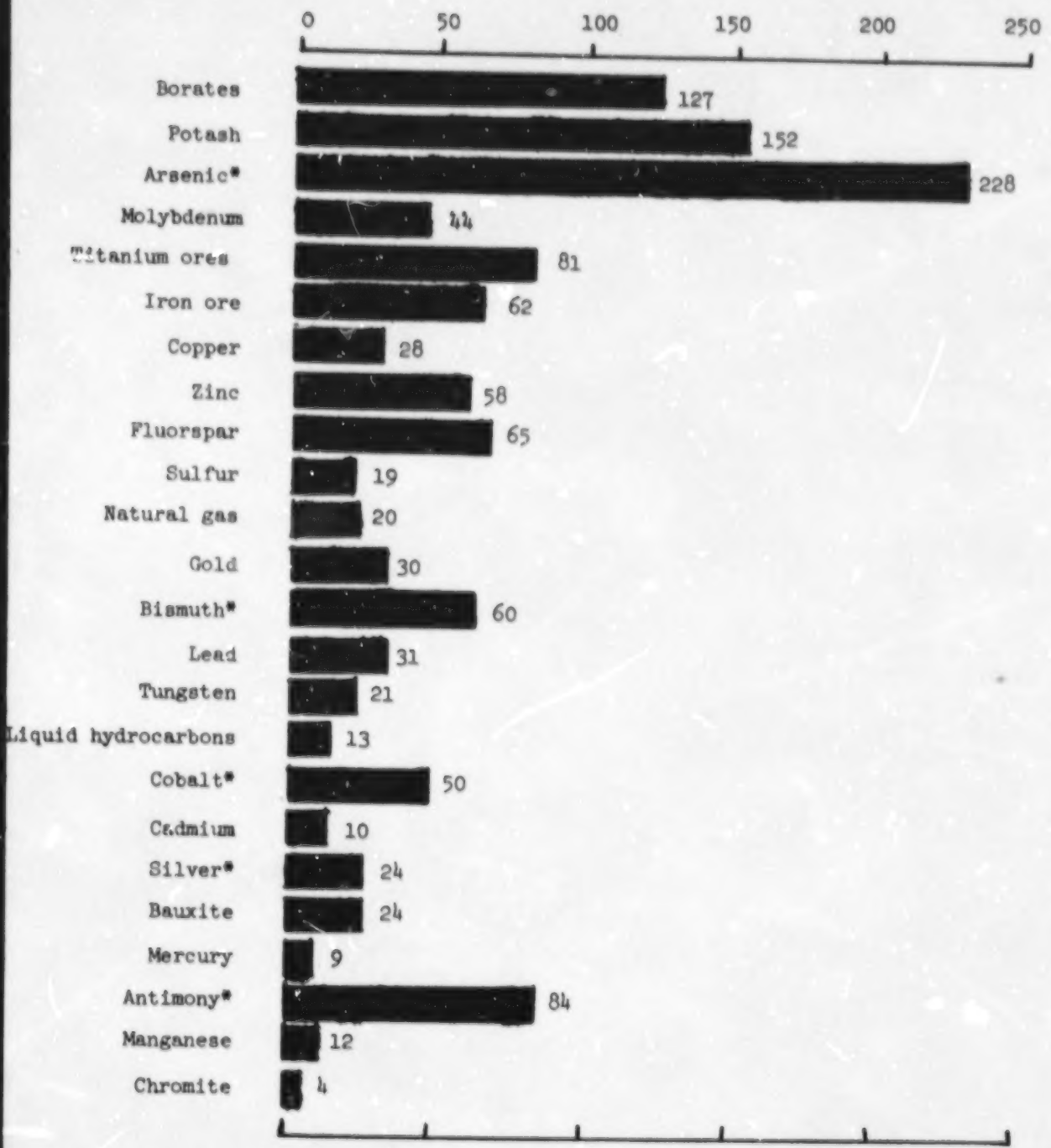
RESERVE-LIFE IN YEARS OF CONSUMPTION AT 1960 RATES

*Obtained chiefly as byproducts



RESERVE-LIFE IN YEARS OF PRODUCTION AT 1960 RATES

*Obtained chiefly as byproducts



COMMODITIES AND THEIR USES*

Antimony - A metal obtained from the mineral stibnite (Sb_2S_3). It is used to impart hardness and stiffness to lead, and these alloys are in pipes, bullets, solder, and storage battery plates. Another alloy containing antimony is pewter.

Arsenic - A metal obtained from three arsenic sulfide minerals. It is used as a poison.

Bauxite - A mineral that is an aluminum hydroxide in nature. There are more than 4,000 applications of aluminum including uses in aircraft construction, awnings, roofing, kitchenware, wire, cans, and automobile parts. Alloys of aluminum are used for machine parts. Copper is a substitute for aluminum.

Bismuth - Found as a native metal and in the minerals bismuthinite (Bi_2S_3) and bismite (Bi_2O_3). It is alloyed with other metals to lower their melting points and is used in fire protection sprinkler devices, electrical apparatus, and other minor applications.

Borates - Soures of boron, including the minerals borax (a sodium borate) and sassolite (natural boric acid, H_3BO_3). Borax is a cleaning compound. It is used in the pottery industry, in heat resistant glass, as a preservative, and in many other ways.

Cadmium - A metal obtained as a by-product from the smelting of zinc. Cadmium is alloyed with other metals for use as anti-friction metal in cars, dental fillings, as a tarnish resistant and rust resistant covering. Cadmium oxides are the yellow and orange pigments in paint.

Chromite - Alloyed with steel, chromium, along with some nickel, forms stainless steel which is used extensively in food processing plants, chemical plants, etc. Chromic oxide is used as a brick-lining in metallurgical furnaces.

Cobalt - Found in association with arsenic and often produced as a by-product of copper or silver mines. It is used primarily in steel to cause it to retain strength and temper at high temperatures.

Copper - Over 150 minerals contain copper, but only 8 of these are important ore minerals. Half of these are sulfides, half are carbonates and oxides. Major uses of copper are in power and telephone lines, switches, electric light sockets, pipes, hardware, cooking utensils, etc.

Fluorspar - (from Charles Park, Affluence in Jeopardy, San Francisco: Freeman, Cooper and Company, 1968) It is an essential mineral with a small total amount used as a flux in steel making. Other uses are making fluorine, of drinking-water, tooth-hardening fame. It comes from the mineral fluorite (CaF_2).

Gold - A metal that has played an important role in shaping man's destiny. It is alloyed with other minerals for hardness or color and used as jewelry, lettering, gilting, in dentistry, and primarily as currency or to back up the value of paper money.

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* Charles M. Riley, Our Mineral Resources (New York: Wiley and Sons, Inc., 1967).

COMMODITIES AND THEIR USES (continued)

Iron Ore - The second most common metal is found in chemical combination with oxygen and water in the minerals hematite (Fe_2O_3), magnetite (Fe_3O_4), limonite ($FeO[OH].nH_2O$), and siderite ($FeCO_3$). The many steels are alloys of iron and other elements.

Lead - This mineral is almost universally associated with zinc and is found as the sulfide ore galena (PbS), oxides cerussite ($PbCO_3$), and anglesite ($PbSO_4$). Lead is used in paint, storage batteries, and electrical cables. Alloys form pewter and solder.

Liquid Hydrocarbons - Petroleum. Used as fuel, lubricant, in medicine, solvents, and numerous other ways.

Manganese - Most valuable deposits are of sedimentary or residual origin. Of all the metals used as steel alloys, manganese is the most important because it removes oxygen and sulfur leaving a "clean," bubble-free metal. There is no substitute known for manganese.

Mercury - The only important ore mineral of mercury is cinnabar (HgS). Mercury is the only liquid metal (at ordinary temperatures) and is used in switches, to extract gold, and in thermometers and medicines.

Molybdenum - The one important ore mineral is molybdenite (MoS_2). Molybdenum is one of the most important alloy metals in steel, giving it shock resistance, strength, and hardness. The steel is used in automobile parts, tools, and machinery.

Natural Gas - Associated with petroleum and used as fuel, carbon black, and as a source of helium.

Potash - The term "potash" is presently used to designate the potassium oxide content of minerals. Salt deposits and brines rich in potash supply the needs for fertilizer and those manufacturing needs such as in making paint, synthetic rubber, and glues. Potash was originally potassium carbonate extracted from wood ash.

Silver - Silver is often a by-product of the production of other metals such as lead, zinc, and copper. About 70% of the world's production of silver is used for monetary purposes. It is also used for sterling, jewelry, and in photographic film and paper.

Sulfur - Native sulfur is found associated with salt domes in the cap rock, in sedimentary beds, and in regions of volcanic activity. It is used in the manufacture of sulfuric acid, fertilizer, industrial and pharmaceutical chemicals, and rubber products.

Titanium - The important ore minerals are ilmenite ($FeTiO_3$) and rutile (TiO_2). It is used in paint and as an alloy to provide resistance to intense heat.

Tungsten - Deposits occur only where mineralization has taken place at high temperatures and pressures. It is used as light bulb filaments, and in high speed cutting tools and drills where its ability to withstand heat without melting is utilized.

Zinc - Found in the sulfide ore mineral sphalerite (ZnS) and oxide ore minerals as well. It is used as a protective coating of steel (galvanizing) and in paint.

INSTRUCTIONS:

3. Restart the audio cassette tape. Listen to the tape and view the slides until the bailiff asks for your decision and you view the slide that indicates the end of the lesson. Then STOP THE TAPE AND SLIDES. A summary of the arguments given by each group at the hearing is given below.

Stop Mineral Resource Abuse	Man is Marvelous
1. Concentrations of minerals are unevenly distributed over the earth and these concentrations are our minable deposits.	1. Ordinary rocks and the ocean are potential sources of mineral deposits.
2. The concentration processes are too slow to renew deposits.	2. Cost rather than volume of the mineral determines whether or not a deposit is mined.
3. Some mineral deposits can literally be mined out.	3. Recycling is a way to renew deposits.
4. When reserve-life in years of consumption and production of commodities based on 1960 rates are compared, shortages are indicated by the number of commodities that must be imported to meet consumption needs.	4. Man is ingenious and will develop the technology required to extract minerals from even meager sources.
5. It is unrealistic to suppose that technology can be developed to mine certain low grade deposits.	

Study this list before rendering your decision as instructed below. Write your decision on your STUDENT RESPONSE SHEET.

DECISION

My opinion regarding the statement, "Mineral resources are finite and essentially nonrenewable," which includes (1) comments regarding the arguments presented, and (2) the identification of at least two gaps in the information provided is as follows:

ANSWERS TO QUESTIONS IN STUDY GUIDE

QUESTION 1 Answers

How many years of reserves at 1960 consumption and production rates remain for the minerals listed below?

Mineral	Years of reserve at 1960 consumption rate	Years of reserve at 1960 production rate
a) Copper	27	28
b) Manganese	0	12
c) Cadmium	10	10

QUESTION 2 Answers

List the commodities according to whether consumption rate exceeds, is equal to, or is less than production rate. Determine what percent of the total number of commodities is represented by each list.

Consumption rate exceeds production rate	Consumption rate equals production rate	Consumption rate is less than production rate
Chromite	Cadmium	Natural Gas
Manganese		Sulfur
Antimony		Copper
Mercury		Molybdenum
Bauxite		Borates
Silver		
Cobalt		
Liquid Hydrocarbons		
Tungsten		
Lead		
Bismuth		
Gold		
Fluorspar		
Zinc		
Iron Ore		
Titanium Ores		
Arsenic		
Potash		
75 % of total commodities	4.2 % of total commodities	20.8 % of total commodities

QUESTION 3 Answers

If the United States cannot produce for itself the quantity of commodities it needs, from what source(s) will the commodities come?

Imports from other countries
Recycled materials
Stockpiles

QUESTION 4 Answers

At 1960 rates, how many commodities have a reserve-life in years of production that is 25 years or less? 10

What fraction of the total number of commodities is this number?

10/24 (less than half)

GLOSSARY

Anticline: a fold that is convex upward. In simple anticlines, the beds are oppositely inclined. In more complex types, the limbs may dip in the same direction.

Continental shelf: gently sloping shallowly submerged marginal zone of the continents, greatest average depth is less than 600 feet.

Crust: outer layer of the earth.

Fault: a fracture or fracture zone along which there has been displacement of the sides relative to one another parallel to the fracture.

Finite: having a definite limit, limited.

Fossil fuel: coal and petroleum.

Grade: expression of relative quality. For example, high grade or low grade.

Metal: constituting over 3/4 of the recognized elements, these substances are typically fusible and opaque, are good conductors of electricity, and show a peculiar metallic luster. Most metals are also malleable, heavy, and solid. Examples include gold and aluminum.

Mine: in general, any excavation for minerals.

Mineral: in this program, a homogenous naturally occurring phase, including fossil and mineral fuels, although principally a product of inorganic processes.

Mineral deposit: in this program, refers to any mass of mineral material, can also refer to only valuable masses (ores).

Nonmetals: in this program, refers to such resources as building materials (sand, gravel, building stone) and fossil fuels.

Nonrenewable resource: a resource which can be used only once and essentially cannot be regenerated by slow natural processes.

Ore: a mineral or aggregate of minerals which, from the standpoint of a miner, can be won at a profit.

Pellets: semi-refined ore produced by a process of agglomeration or sticking together. The iron ore is crushed, the iron oxidized, concentrated, and cemented together, and the waste discarded.

Reserve: generally refers to known ore bodies that may be worked at some future time. The information that tells exactly how much and how rich an ore deposit is varies and consequently the certainty of the estimate of these factors will vary. Reserves are sometimes grouped into two types:
(1) those that are identifiable concentrations that may be economically recoverable in the future
(2) those that are economically profitable to work.

Reserve-Life in Years of Consumption: the number of years of consumption remaining for a resource based upon the reserve and the rate of consumption at a particular time.

Reserve-Life in Years of Production: the number of years of production remaining for a resource based upon the reserve and the rate of production at a particular time.

Resource: a supply

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SCRIPT FOR LEARNING CARREL LESSON

6.10

MINERALS

ENVIRONMENTAL STUDIES

A Cooperative Project of the Department of Geological Sciences and the Science Education Center

THE UNIVERSITY OF TEXAS AT AUSTIN

1

2

Please read page 1 in your Study Guide and look over the Glossary in the back. Please stop the tape and do this if you have not already done so.

(Sounds of room full of people, conversation, body motion)

(Bailiff) "Will everyone please rise. You may be seated, the judge is with us."

3

Welcome to Learning Carrel Lesson Number 10. You are the judge.

(Soft conversational sounds in background)

We are waiting to begin the hearing in just a few moments now. This hearing has caused quite a stir, you know. The group called

---

4

Stop Mineral Resource Abuse feels it has sufficient data to determine once and for all the validity of the primary statement of their organization. If they can get a judgment upholding the validity, they intend to make a federal case out of it.

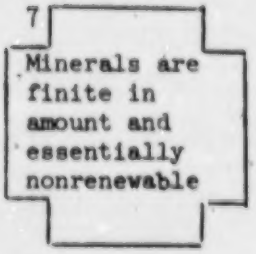
5

Speaking in opposition to the statements is the group called Man is Marvelous. Their basic position is that man can solve all of the problems he creates.

6

I believe the speaker for the mineral abuse group is preparing to give a copy of the statement to the judge.

7



Yes, the judge should be reading it now.

The speaker for the mineral resource group is ready to begin.

8

(SMRA) "Your Honor, ladies and gentlemen, as you know the group I represent is deeply concerned about the state of mineral resources, particularly here in the United States. Minerals have helped make the United States a world power. The two nations best endowed with minerals are the United States and Russia. We contend that minerals are finite in amount and essentially non-renewable. We are convinced that our mineral resources will soon run out if we and a possibly larger future population continue using minerals at our present rate. We will present enough evidence to demonstrate that our contention is valid, and we must begin to take action immediately to reverse the dire trends. Our first witness to testify is Slim Hutchins."

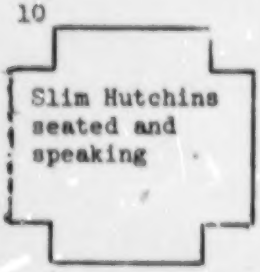
9

(SMRA) "State your name and occupation."

(Hutchins) "Slim Hutchins, doing nothing now, but I used to be a miner."

(SMRA) "Please be seated, Slim."

10



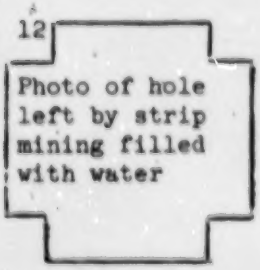
(SMRA) "Do you believe minerals are finite in amount?"

(Hutchins) "Before proceeding with my answer to that question, let me say it's a privilege to speak at this hearing. Yes, I believe that statement is true. I've been in the mining business for a long time, heard many a story and seen many a mine. Believe me,"

11

(Hutchins) "... a mineral deposit isn't like trees or corn -- you can replant these, and if you're careful, you can keep them up forever."

12



(Hutchins) "Once a mineral deposit is mined out, nothing remains but the hole, and who wants holes? And then think of all those old ghost towns. They're reminders that the people left because there was nothing left to be mined. Holes don't keep people."

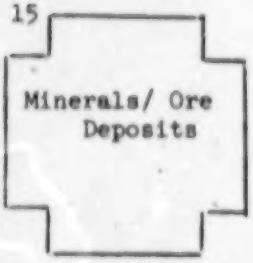
13

(MIM) "Your Honor, with all due respect to Mr. Hutchin's experience, we believe his argument is misleading."

14

(MIM) "First of all, not all mineral deposits are mined, the deposit must be one that is profitable to mine."

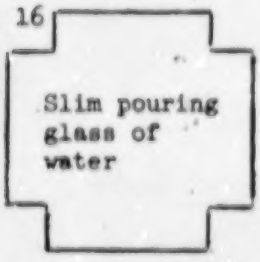
15



(MIM) "Incidentally, when this is the case, we call the deposit an ore deposit. Mr. Hutchin's mines weren't necessarily mined out because they ran out of mineral, some mineral may still have been there -- it was just no longer profitable to take it out."

(Hutchins) "Now just a ding-dang second there! You didn't understand what I tried to tell you!"

16



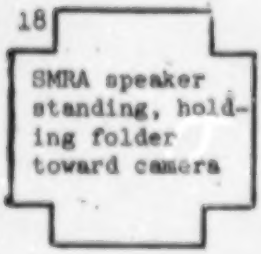
(Hutchins) "Mineral deposits are like this glass of water (sound of water being poured). If you keep taking something out and you don't anything back in,"

17

(Hutchins) "... you're eventually going to have nothing left."

(SMRA) "Thank you, Slim."

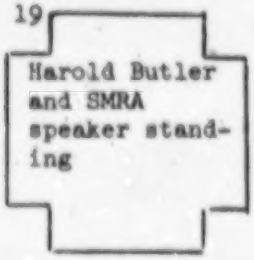
18



(SMRA) "We'd like to introduce Mr. Harold Butler now."

(Sound of Butler coming to the stand, and Slim sitting down)

19

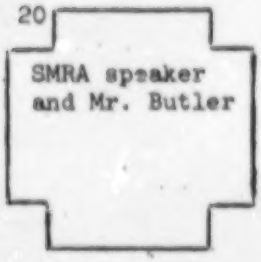


(SMRA) "Please state your name and occupation."

(Butler) "Harold Butler, geologist."

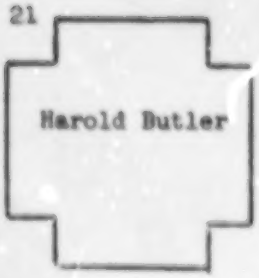
(SMRA) "You may be seated, Mr. Butler."

20



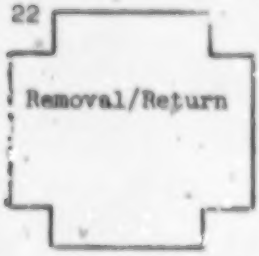
(SMRA) "Would you please describe your view of finiteness and renewability of minerals?"

21



(Butler) "Thank you. Your Honor, Slim is correct, up to a point."

22



(Butler) "We are removing minerals from the earth, but nature is returning them at the same time. The problem is that the rate of return is too slow to make a difference when compared to the rate of removal."

(Kutchins) "Kind of like running water out of a bathtub faster than you're putting it in!"

(Butler) "Yes, Slim. The best example of this is the situation with fossil fuels."

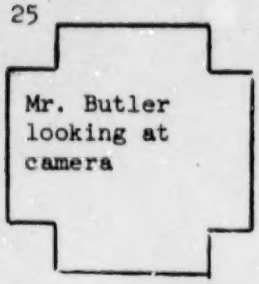
23

(Butler) "In one year, man uses what it took nature 200,000 years to produce. Our use is 200,000 times faster than natural production."

24

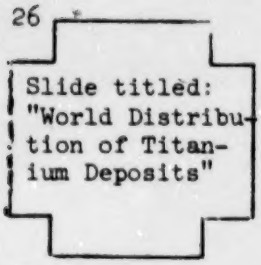
(Butler) "Bauxite ore, from which aluminum is obtained, takes from 50 million to 60 million years to form. It can be depleted by mining from 5 to 50 years."

25



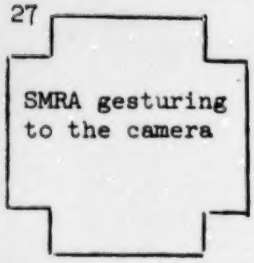
(Butler) "You could thus say that minerals are essentially nonrenewable. As for minerals being finite in amount, we need to look at other aspects of mineral deposits -- their distribution and abundance. We observe that minerals are not equally distributed over the earth. The processes involved in forming the minerals are such that the deposits are concentrated, and the places having the concentrations are scattered. No one country has minable concentrations of all minerals. For example,"

26



(Butler) "... look at the world distribution of titanium minerals. Minerals are concentrated where you see the circles. The larger the circle, the greater the amount of minerals. Notice that only certain countries have them."

27

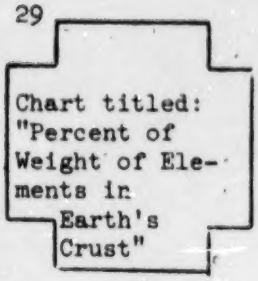


(SMRA) "Excuse me, Mr. Butler. Just for clarity, would you describe what is meant by minable concentration?"

28

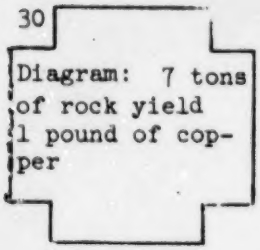
(Butler) "That's not easy to answer. Economics, politics, and technology are involved, as well as geology. However, to give you some idea of the amounts we're dealing with, it's convenient to compare the abundance of elements to their abundance in a hypothetical 'average' rock of the crust."

29



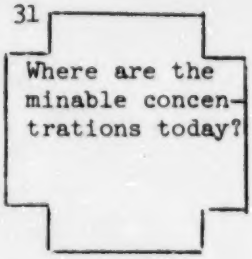
(Butler) "Most of the metals and nonmetals with which we are concerned are in amounts of less than one percent by weight of the earth's crust. Taking copper as an example, its average crustal abundance is 0.007 percent."

30



(Butler) "In order to recover one pound of copper from an average rock, seven tons of rock would have to be sent to the smelter."

31

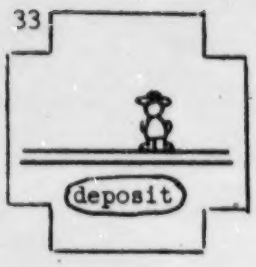


(Butler) "The problem becomes one of exploration, to find the concentrations that are minable. This is difficult to do. The deposits that are easy to find have already been found."

32

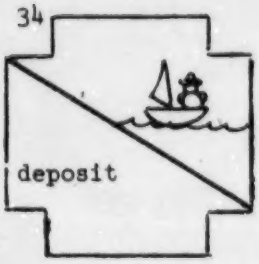
(Hutchins) "You said it! Those deposits aren't out there waving a flag saying, 'Here I am, come get me!'"

33



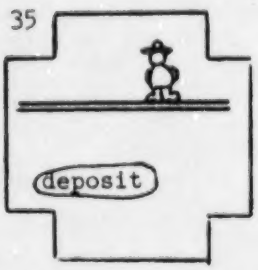
(Butler) "The remaining deposits are hidden under surface layers,"

34



(Butler) "... and are underwater on the continental shelves,"

35



(Butler) "... or they may be at great depths and require great cost or advanced technology for removal. At the same time, each deposit is unique. It may not be located where you expect it to be, based on the location of other similar deposits."

36

(Butler) "You might miss finding a deposit because you were looking for it in association with a structure such as an anticline, when it was actually associated with a fault."

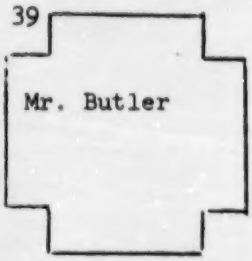
37

(Butler) "Added to these problems are the effects of the demands of the environmentalists who want us to set aside mineral sites as wilderness areas."

38

(Butler) "Another example of a mineral site being eliminated is when cities pave over and build on potential supplies of sand and gravel."

39



(Butler) "To sum up, the parts of the crust where nature has done the enriching are limited in number and volume, and these basically are our minable products. People even fight for ownership of them, and that's where the money and power is. There is just not enough of these concentrations."

(Bailiff) "Order! Let's have order in this hearing room! The next speaker is the representative of the Man is Marvelous group."

40

(MIM) "Your Honor, our group intends to be much more brief and to the point. We would like to call Mr. Randall Carter to testify for us at this time."

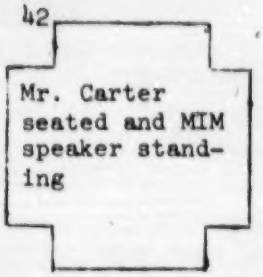
41

(MIM) "Please state your name and occupation."

(Carter) "Randall Carter, economist."

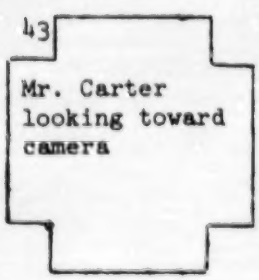
(MIM) "Please be seated."

42



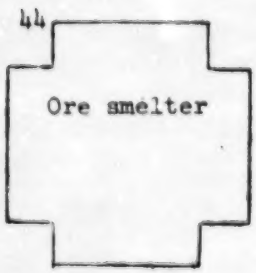
(MIM) "What do you see as a reasonable and sane view of mineral resources?"

43



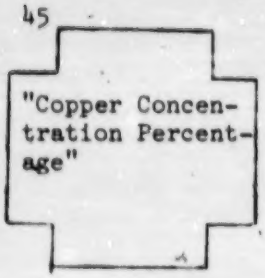
(Carter) "I say that mineral resources are not finite in amount, they are virtually inexhaustible, depending upon man's cleverness. I believe the evidence supports that man has already demonstrated his ingenuity in conceiving of new ways to extract minerals from rocks with smaller and smaller concentrations. I'd like to point to two examples where this has been done, the situations with iron and copper."

44



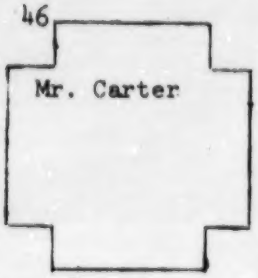
(Carter) "The technique of concentrating iron by forming pellets has made low grade iron ore more desirable for use than high grade ore."

45



(Carter) "The trend since 1900 in copper mines has been toward use of large scale deposits with less ore per ton. Deposits having around 3% copper were first mined in the 1800's. Later, from about 1910 to 1920, this declined to about 2%, and today deposits of approximately 1% and 1/2% are mined. Although you get less ore per ton, there are greater quantities of the lower grade material."

46

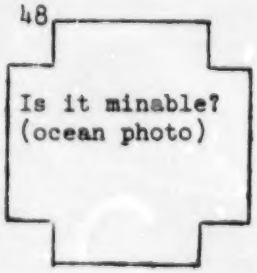


(Carter) "But to be realistic, mineral resources are defined not by volumes of concentrated mineral, but rather by cost."

47

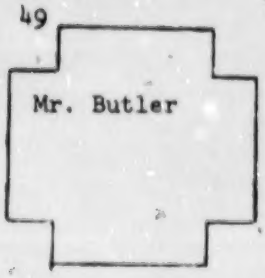
(Carter) "There is an ore body for every economic situation. With the appropriate technology, we can mine ordinary rock,"

48



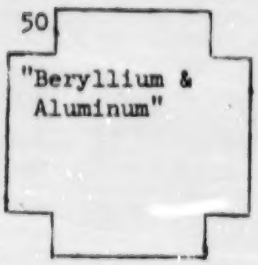
(Carter) "... or even sea water."

49



(Butler) "I'd like to make one further comment if I may. Because of the natural processes of deposition, the volume of lower grade material does not always increase continuously as in the case of iron and copper as suggested by Mr. Carter. Some deposits, such as beryllium and aluminum, can literally be mined to the point of depletion. Look at this illustration, Your Honor."

50



(Butler) "Beryllium is mined from high concentrations found in pegmatites. Once these deposits have been depleted, the next most abundant source of this commodity is in the clays having much lower concentrations. Notice the gap in grade. There is no middle grade to speak of. This represents a technological and economic gap as well. Is it realistic to suppose we can develop the technology to mine such low grade deposits?"

(Hutchins) "Yeah, it took over 40 years to develop the pelletizing process."

(Butler) "Are the demands for the commodities great enough to offset the costs of developing such a technology?"

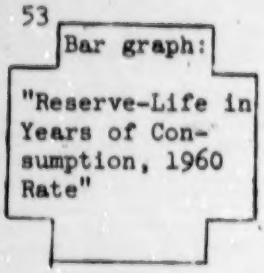
51

(SMRA) "Thank you, Mr. Butler. Our group will now provide additional evidence proving the exhaustibility of our mineral resources here in the United States. Our mineral reserves are being progressively depleted due to our high standard of living and population increase."

52

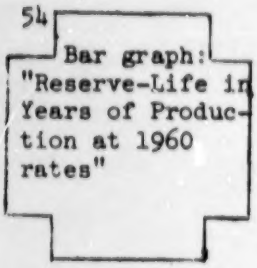
(SMRA) "We want more, and there are more of us wanting. The result -- increased demand, production, and consumption."

53



(SMRA) "In fact, the rate of consumption of mineral reserves in the United States is so great that in many cases, our rate of production can't keep up with it. Look on the graph at the commodity, gold. Assume that we can produce gold at the same rate we consume it and that we have a fixed amount of the commodity in reserve. We have only enough gold reserves to be able to consume gold at the 1960 rate for 20 years. On page 4 in your Study Guide you will find a graph like this one..."

54



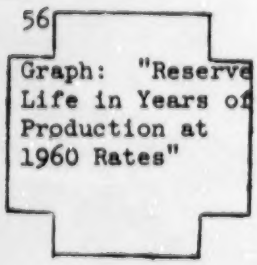
(SMRA) "... of the reserve-life in years of consumption and an overlay graph of the reserve-life in years of production. If we are using up a commodity faster than we can produce it, the reserve-life in years of production will be longer than the reserve-life in years of consumption. From your study of this evidence, you will no doubt notice the abundance of short reserve lives. This evidence supports our concern over the state of our mineral resources."

55

(SMRA) "Mr. Bailiff, we wish to call a recess for the judge to further examine the evidence on pages 2, 3, and 4 in the Study Guide."

(Bailiff) "A recess is so called. Please stop the tape."

56



(SMRA) "You probably noticed from this graph that consumption exceeds production for 78% of the commodities listed."

57

"Reserve-Life in Years of Production at 1960 Rates"

(SMRA) "Did you further notice that at the 1960 rate of production, 10 out of 24 commodities will have been depleted by 1985? That is just under 1/2 of the listed commodities. If you noted that the commodity manganese was running short,"

58

Photo of molten iron

(SMRA) "... note also that manganese is a catalyst in the steel-making process, and no satisfactory substitutes have been found for it, even after looking for 70 years."

59

Group photo -- SMRA speaker standing and speaking

(SMRA) "This evidence is proof enough that we in the United States are running out of minerals and becoming increasingly dependent upon imports. It is proof enough that minerals are finite in amount."

60

Group shot -- MIM speaker standing and speaking

(MIM) "The evidence presented from the Stop Mineral Resource Abuse Association needs to be examined more closely in order to discover its flaws. The production and consumption rates presented are based upon proven and obtainable reserves. That is, deposits that we know exist and that we are technologically able to remove."

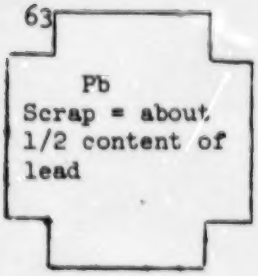
61

(MIM) "As we have pointed out previously, our reserves could potentially be unlimited. And even our worthy opponents would agree that we really don't know how much reserve we actually have. Once again, our point is made that mineral resources are virtually unlimited in volume. Furthermore, man is not just a remover of minerals,"

62

(MIM) "... he is also returning minerals through recycling efforts. Such minerals as copper, lead, and aluminum are presently being recycled."

63

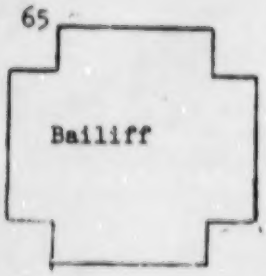


(MIM) "Scrap makes up nearly 1/2 of the metal content of the lead used in 1971."

64

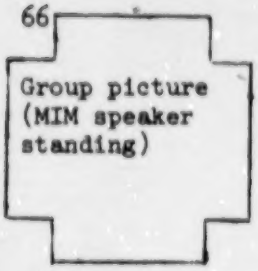
(MIM) "This kind of information was not included in the reserve-life graphs that were shown by the opposition. We find that little cause for the alarm that the Stop Mineral Resource Abuse Association is trying to create."

65



(Bailiff) "Are there any more testimonies to be given? If not, we will proceed with the concluding statements. Will the speaker for the Man is Marvelous group begin the summation?"

66

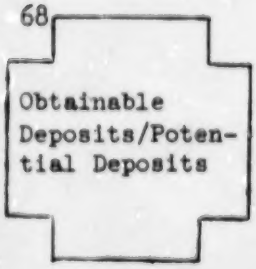


(MIM) "We have repeatedly shown, Your Honor, that the statement, 'Mineral resources are finite in amount and essentially nonrenewable,' cannot be valid if you consider that the crust and oceans of the earth are potential sources of mineral deposits."

67

(MIM) "Furthermore, whether or not a deposit is mined depends upon the cost structure at that time, not on the volume of high grade mineral."

68



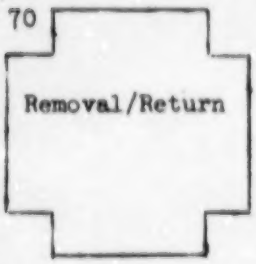
(MIM) "Finally, man will continue his recycling efforts, essentially renewing his resources and will conceive of the technology to extract minerals from even the most meager source. Thank you."

(Bailiff) "We will nov hear the speaker for the Stop Mineral Resource Abuse Association."

69

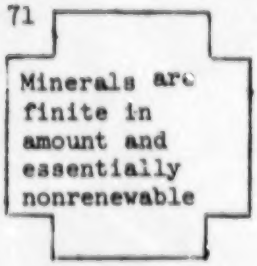
(SMRA) "It is clear that mineral resources are finite in amount and nonrenewable. Because of natural processes, minerals are concentrated in various locations on the earth."

70



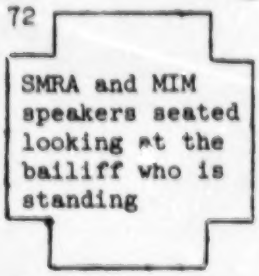
(SMRA) "The concentration processes are too slow, however, to be able to renew deposits at a rate greater than our use. And yet, these concentrations are the ones that can be utilized given our present technology. The very fact that shortages are apparent, that we in the United States are having to import minerals, attests to the validity of our statement."

71



(SMRA) "Minerals are finite in amount. Minerals are essentially nonrenewable."

72



(Bailiff) "Thank you." (Pause) "Your Honor, we will now recess to await your decision. Please turn to page 8 in your Study Guide and stop the tape.

(Background conversation and noise)

73

LESSON 6.10: MINERALS

STUDENT RESPONSE SHEETS

Name _____

Date _____

LESSON 6.10: MINERALS

STUDENT RESPONSE SHEET

Question 1: How many years of reserves at 1960 consumption and production rates remain for the minerals listed below?

Mineral	Years of reserve at 1960 consumption rate	Years of reserve at 1960 production rate
a) Copper		
b) Manganese		
c) Cadmium		

Question 2: List the commodities according to whether consumption rate exceeds, is equal to, or is less than production rate. Determine what percent of the total number of commodities is represented by each list.

Consumption rate exceeds production rate	Consumption rate equals production rate	Consumption rate is less than production rate
____% of total commodities	____% of total commodities	____% of total commodities

Name _____

Date _____

LESSON 6.10: MINERALS

STUDENT RESPONSE SHEET

Question 3: If the United States cannot produce for itself the quantity of commodities it needs, from what source(s) will the commodities come?

Question 4

At 1960 rates, how many commodities have a reserve-life in years of production that is 25 years or less?

What fraction of the total number of commodities is this number?

Name _____

Date _____

LESSON 6.10: MINERALS

STUDENT RESPONSE SHEET

You were the judge at this hearing. What is your decision?

DECISION

My opinion regarding the statement, "Mineral resources are finite and essentially nonrenewable," which includes (1) comments regarding the arguments presented, and (2) the identification of at least two gaps in the information provided is as follows:

Signed Judge _____

_____ day of _____, 19_____
(Day) (Month)